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CONSOLIDATION WITH FRP OF GLUED-LAMINATED TIMBER BEAMS

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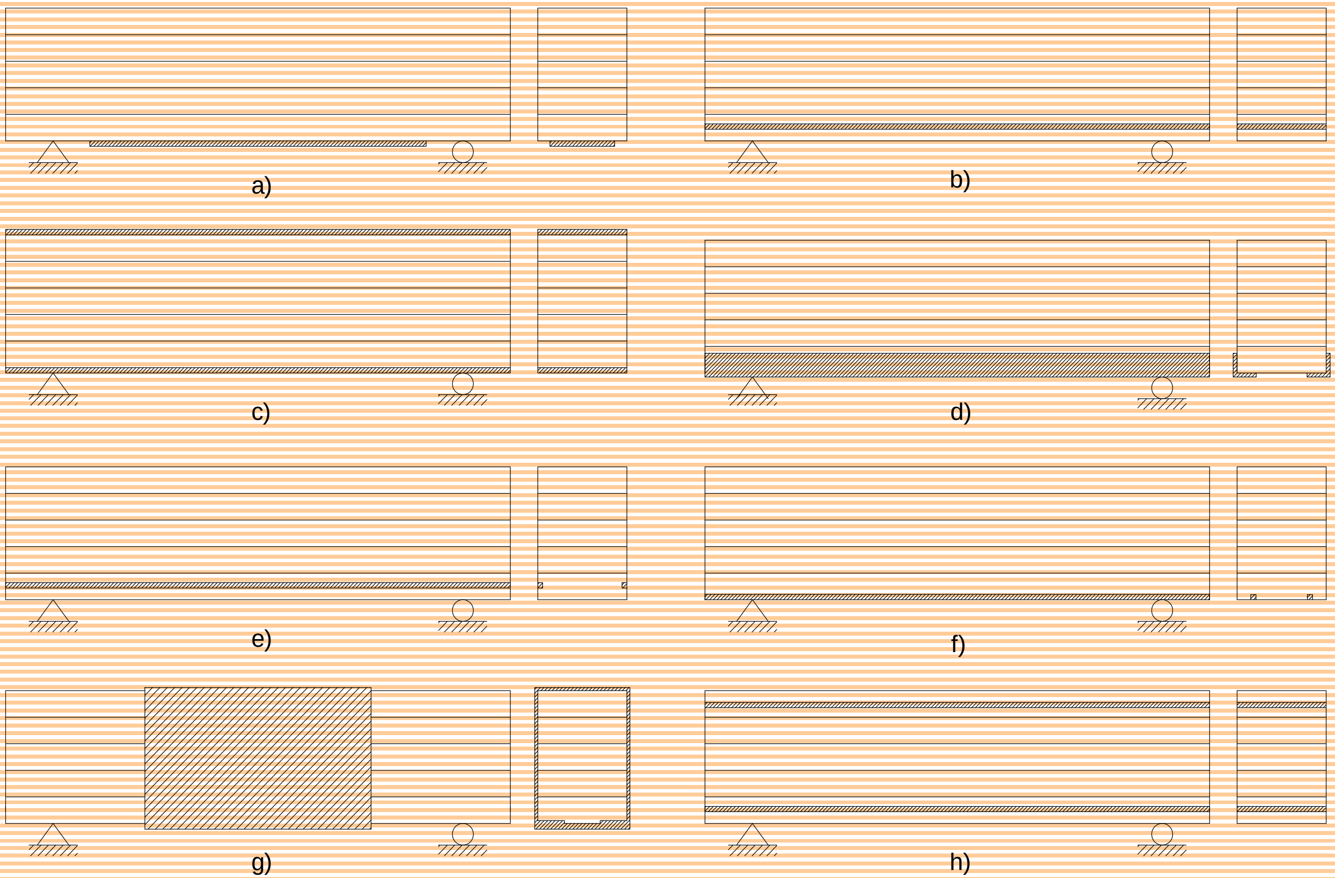
Introduction

- Wood, as a natural product, has a number of advantages and disadvantages for use in structural elements in buildings.
- A first step in reducing the variability of characteristics of wood products was the invention of glued laminated wood.
- Another way to remove certain deficiencies of wood is the consolidation of the elements. It can be done with two purposes, namely:
  1. correcting defects at existing elements
  2. increase the bearing capacity or decrease the dimensions of new elements
- The first solutions for the consolidation of wood elements were the classical ones (with steel or wood elements), after those appeared more modern strengthening solutions using glass or aramid fibers and lately using carbon fibers products.

Below are different types of experimental consolidation solutions, some that can be used on existing elements and some for new elements



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The main consolidation solutions with products based on carbon fibre that exists until now have led to the following conclusions:

- The coefficient of variation of bearing capacity decreases by strengthening effect;
- Enhancing strengthening leads to rigidity and resistance;
- Reinforcing effects are more important for low resistance wood than for high resistant one;
- Fibre tissues have lower performance than flat bands;
- The failure of the elements at bending is done for both consolidated and unconsolidated ones, through stretching.

The experimental attempts done until know had some special features which may have some influence on the final conclusions and that are different from our features:

- Smaller size of the elements;
- A separate, parallel trial of unconsolidated elements and other for consolidated ones;
- The load tests concentrated in three and four points;
- Different consolidation technology;
- Different theoretical calculation models (linear and nonlinear analyses).

The objectives of the experimental attempts carried out by us have been to determine many parameters, as follows:

Å Consolidation technology;

Å Strengthening effect over elements that were initialy bend until breaking and later were consolidated;

Å Strengthening type (with carbon fibre strips or flat bands);

Å Anchor mode of consolidation (without anchoring or anchored at the ends);

Å The treatment of fissures from the initial phase of trial (injected cracks and noninjected);

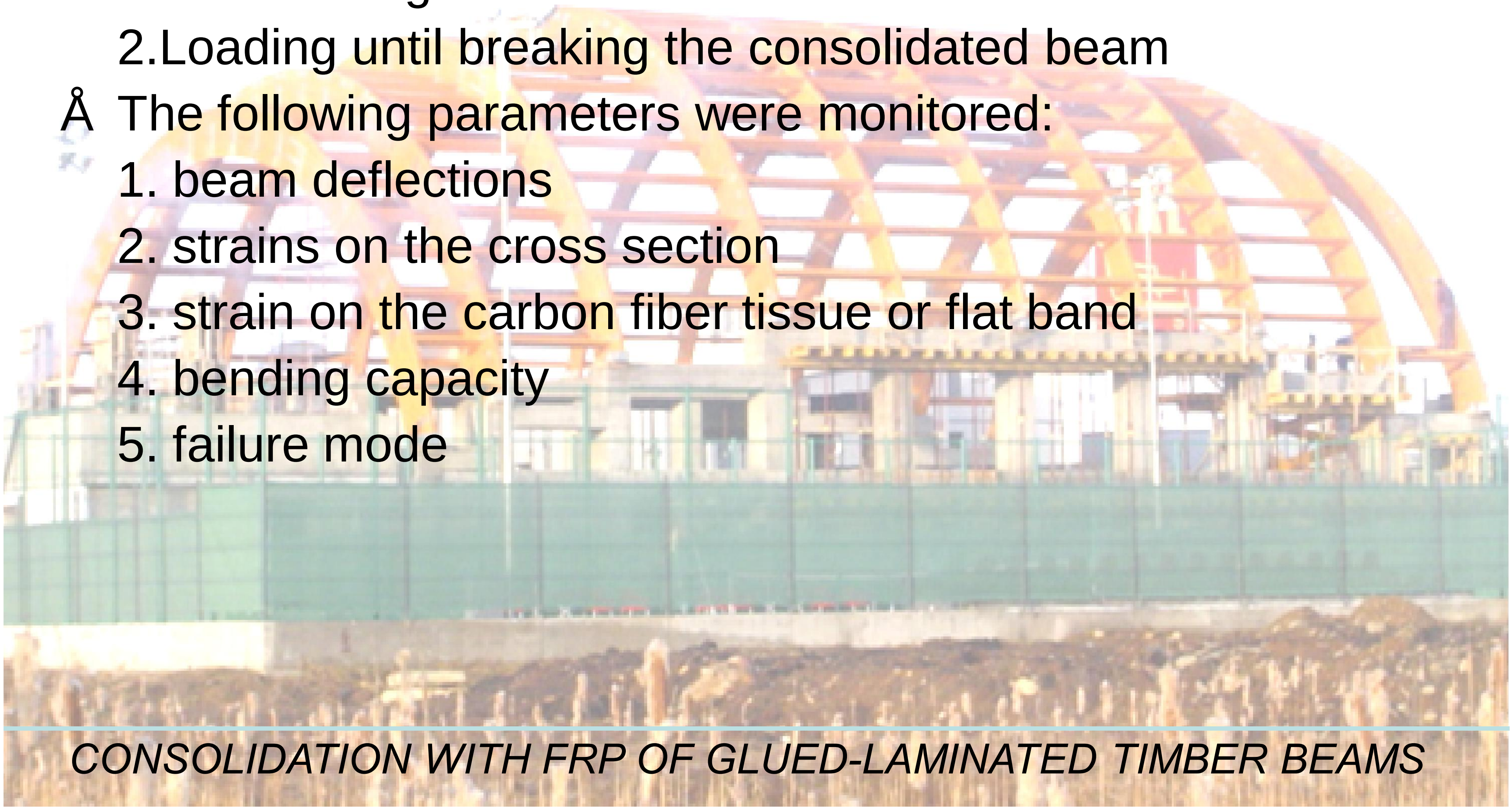
Å The experimental tests consisted of 2 cycles of loading:

1.Loading until we reached 30% of the maximum force and unloading afterwards

2.Loading until breaking the consolidated beam

Å The following parameters were monitored:

1. beam deflections
2. strains on the cross section
3. strain on the carbon fiber tissue or flat band
4. bending capacity
5. failure mode



The stand was designed for a four points load and for reading the results we used mechanical and electronical displacement transducers and strain gauges

Technical characteristics of the types of strengthening used in our experimental models:

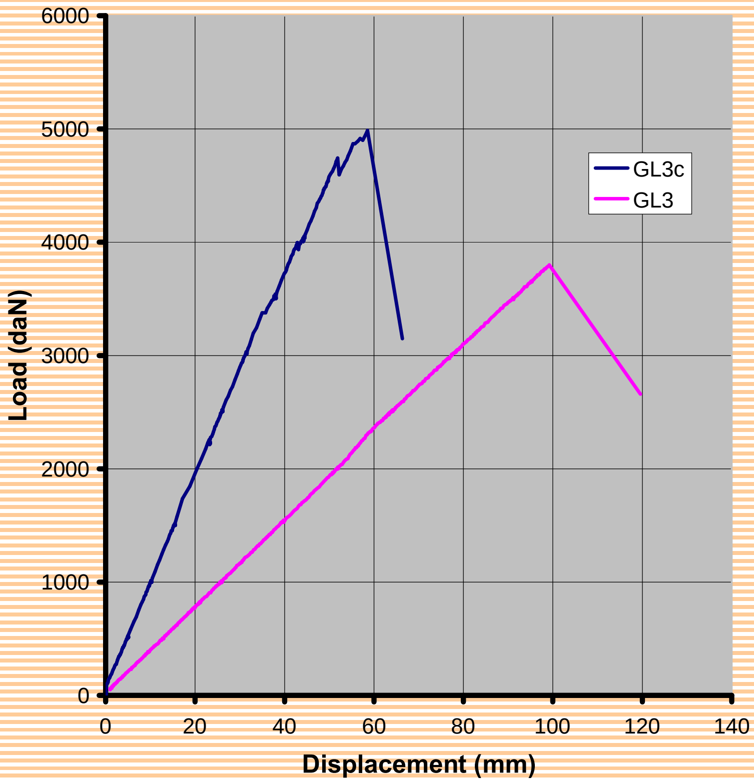
Element	Characteristics of strengthening
GL 2C	A carbon fibre tissue + injected cracks
GL 3C	Two carbon fibre tissues, anchored + injected cracks
GL 5C	Two carbon fibre tissues, anchored + without the injection of cracks
GL 6C	A carbon fibre flat band, anchored + without the injection of cracks
GL 7C	A carbon fibre flat band, anchored + injected cracks
GL 24/2C	A carbon fibre tissue, anchored + without the injection of cracks
GL 24/3C	Two carbon fibre tissues, anchored + without the injection of cracks

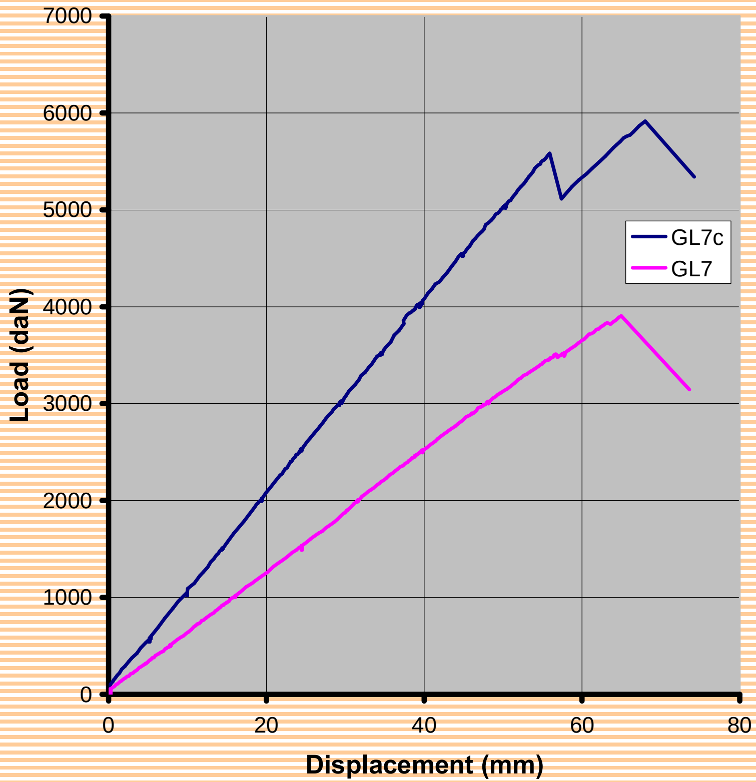
Below you can see some of the condition of the beams that were first bend until breaking before the consolidation

Below you can see the manufacturing technology (the injection of crack using MAPEI Mapewood Gel and the application of carbon fiber tissue MAPEI Mapewrap using MAPEI Mapewood Primer and MAPEI Mapewood Paste)

Below you can see the manufacturing technology (the anchorage at the ends and the application of carbon fiber flat band using MAPEI Mapewood Primer and MAPEI Mapewood Paste)

In the Load-Displacement diagrams you can see the increase of the bearing capacity and the decrease of the displacement





The summary of the results of the experimental tests is found in the table below

Element Type	Experimental results				
	Loads		Displacement under loading		Ratio of displacements
	$P/2_{max}$ N	ΔP, -	$f_{max,}$ mm	f , mm	Δf, -
GL 2	41100	-	88.55	-	0.46
GL 2C	48450	1.18	76.88	41.15	-
GL 3	38000	-	99.22	-	0.41
GL 3C	49870	1.31	58.54	40.84	-
GL 5	46750	-	74.06	-	1.05
GL 5C	62590	1.34	127.35	77.95	-
GL 6	40150	-	63.80	-	0.59
GL 6C	89920	2.24	86.00	37.93	-
GL 7	39050	-	64.98	-	0.58
GL 7C	59140	1.51	68.02	37.8	-
GL 24/2	35870	-	54.25	-	0.62
GL 24/2C	58900	1.65	69.69	34.05	-
GL 24/3	36870	-	60.58	-	0.688
GL 24/3C	60470	1.64	79.04	41.72	

Conclusions

- All the consolidated beams showed an increase of the bearing capacity (minimum 18%). The lowest increase was recorded at the beam without anchoring at ends
- The displacement was reduced with 40-50%, except a beam that had large cracks and weren’t injected
- The breaking occurred without crushing in the compressed zone and the carbon products were separated from the wood by delamination
- New cracks have developed, different from the initial ones
- There was no separation between the wooden slats. Cracks started from nodes or from finger joint.
- The experimental program is still in progress and will be compared to the theoretical calculations.

Thank you for your attention!